Project Document Summary

Project title	Efficient utilization of organic solid wastes for energy and resource recovery and GHG abatement
Requesting Country	India
Project type	Full project
Duration	5 years
GEF implementing agency	UNDP
Local implementing agency	ANERT, Kerala
Eligibility	India ratified the UNFCCC on November 1993
GEF Focal Area	Climate Change
GEF programme framework	Operational Programme 6

Summary

Inspite of having a very high energy potential, the large quantity of organic waste from agro-based industries, such as rubber, tea, coffee, food processing and the municipal wastes from small towns are not exploited to the maximum. These are due to barriers such as the availability of suitable technology, financial support for the initial projects and capabilities for operation and maintenance of the systems for energy generation from waste. The project will thus target the removal of the barriers responsible for the lack of penetration of the waste treatment technology in these sectors. The project model involves the technology adaptation for specific sectors of industry and the removal of barriers such as the lack of information and capacity building. An important project component of the formation of energy service companies would lead to the sustainability and replication of the model for utilizing the organic wastes from the plantation industries, food processing units and small towns for meeting the energy demand.

Project cost and financing

	Million US $	Percent
Total project cost	9.923	100
GEF Financing	6.29	63.4
Co-financing		
Bilateral	0.97	9.4
MNES	0.76	7.7
State government	0.55	5.6
State Nodal agencies	0.40	4.1
Users	0.92	9.8

Project Brief

1.0 Background and context

1.1 Energy consumption and bioenergy potential

There is an increase in the demand for energy due to increasing industrial and agricultural activities. It has gradually increased from 64.9 million tonnes of oil equivalent (MTOE) in 1973 to 112.6 MTOE in 1983 and to 201.9 MTOE in 1993, indicating a constant annual growth of around over 6% as against the world average of around 1.5% during the same period. The major share is in the consumption of coal which is around 57.9%, followed by oil and wood fuel which is 30.9% and 20-30% respectively. Wood fuels are an important source of energy in the domestic sector. Use of fossil fuels for meeting the rising commercial and domestic energy demands has a significant negative effect on the environment.

India has vast resources of renewable energy and a number of technologies have been developed to harness them. There is huge potential to generate energy from organic waste using a suitable technology package. The estimated potential is 1700 MW of power from urban, municipal and industrial wastes. In India, the total amount of wastes from rubber, tea and coffee processing are 12.4 million litres, 0.034 million tons and 0.195 million tons per annum respectively. The food processing industry, which is fifth in size in the country results in the generation of 0.47 million tons of waste per annum. The total energy generation from rubber and tea would be 259 TJ and 130 TJ respectively and that from food processing is 331 TJ. The project concentrates on agro-based industries such as the plantation industry and food processing industry and the municipal wastes from peri-urban areas in the southern states of India.

1.2 Bioenergy technology and its status

The organic waste from various sources can be treated by either a biochemical or thermochemical route. Biochemical conversion through anaerobic digestion will result in the energy generation. Thermochemical conversion involves the burning of wastes to produce energy. The treatment method depends largely on factors such as quantity and quality of wastes, climatic conditions, local requirements etc. In India, bioenergy technology for the treatment of high strength wastewater from sewage, distilleries, pulp and paper is common. The reason that biomethanation systems are installed for wastewater from these sources is the enforcement of limits imposed by the pollution control boards for the discharge of the waste into streams. The number of existing biomethanation units in distilleries is 145 while the number of units is 254. In pulp and paper, the ratio of biomethanation plants to the total number is still lower at 0.014. However, technology for organic wastes from the other small-scale agro-based industries such as the plantation industry, fruit and vegetable processing

to the same extent. A few available processes are either too expensive or are reliable only for very large-scale plants. Although the total potential for the energy recovery from the wastes is about 1700 MW in the year 1999-2000, installations for the recovery of energy from wastes was about 8.4 MW, which is the maximum, compared to the previous years. The installations for the total recovery of energy from wastes are about 15 MW. These efforts are largely due to programmes of the Ministry of Non-conventional Energy Sources and the financial schemes and incentives of nodal agencies.

1.3 Industrial sectors

Four different agro-industry wastes and the municipal wastes from small towns are considered in this study.

1.3.1 Rubber industry

India is the fourth largest natural rubber producer in the world. Kerala is the largest producing state and accounts for 94% of the total production. The natural rubber is marketed as sheet rubber, crepe rubber, preserved field latex and concentrates or block rubber.

During the processing of natural rubber, an enormous quantity of water is used and the effluent generated has a high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). This is due to the presence of traces of rubber and substances such as carbohydrates, proteins, lipids, organic and inorganic salts and chemicals used in processing, which also lead to an objectionable odour. Before discharging the effluent, a considerable reduction in BOD and COD is essential. On an average, 20 litres of effluent are generated for every kilogram of processed rubber, amounting to 12.4 million litres annually for the country. The activated sludge method is the commonly used treatment method. However anaerobic treatment of rubber effluents which is currently not practiced in India has a very high potential for energy generation in the form of a high calorific fuel- biogas that can be utilized in the processing unit.

1.3.1.1 Energy requirements for processing of rubber

In general the processing operations carried out in a rubber product-manufacturing unit are highly energy-intensive and the energy requirement for processing different kinds of rubber does not vary significantly. The major processing operations which are carried out in a factory are mastication/mixing, extrusion, calendering and moulding. The energy requirements for dry rubber processing are in the range of 20-30 GJ per tonne.

1.3.2 Tea industry

India is the largest tea producing country in the world and produced about 0.87 million tons of black tea in 1998. About 432,000 hectare of land is under tea cultivation. Northeast India produces a wider variety of tea than any other growing area in the world. Tea is cultivated mainly in Bengal (Darjeeling and Dooars), Assam and Cachar. In the south, tea is grown in Tamil Nadu and Kerala's hilly Western Ghat region. India has over 300 major tea companies and has over 12,000 large tea estates. Overall, India accounts for 1300 tea factories and 37,000 of large and small estates. The ratio of thermal to electrical energy use in tea industry is about 85:15. The theoretical energy requirement to remove the moisture from one kg of made tea is about 1.9 kWh, whereas the actual energy consumption varies from 4 to 7 kWh. This depends on process parameters and regional climate factors. The specific energy consumption varies from 4 kWh/kg of made tea to 10.4 kWh/kg of made tea. In Sri Lanka and India, the total specific thermal energy consumption varies between 3.2-6.84 kWh/kg of made tea. The specific electrical energy consumption is about 0.6-0.7 kWh/ kg of made tea.

The thermal energy supply to the tea industry is mainly from coal, fuel oil and firewood. Most northern tea estates use coal and natural gas as the thermal energy source, and in southern India, it is coal (20%), firewood (20%) and furnace oil (20%). Considering the fuel utilization pattern in tea factories, the annual consumption is about 130000 tons of coal, 642 million litres of fuel oil, 780000 tons of firewood and 660 GWh electricity.

1.3.2.1 Waste generation

Rejected green leaves, small quantities of leftovers and litter are the major wastes generated in the tea industry. On an average, the tea industry generates about 100 kg of waste green leaves and litter/ton of made tea. During the drying, tea leaves and fibers could be blown from the dryer. On an average, the blowout is about 2-4% of the made tea. In some factories, these fibers are pulverized and recycled in process as the re-conditioner (RC–powder) and in some cases, these fibres and blown outs are de-natured, and used as fertilizer for tea plantations. The waste has a high organic content and can be suitably digested to produce biogas that can be used to meet the thermal requirements of the industry.

1.3.3 Coffee processing unit

The total coffee production in India is around 2.5 lakh MT and Karnataka is the leading state with 70% of the production followed by Kerala and Tamil Nadu. Coffee is processed by wet processing or by the dry method. Preparation of coffee by the wet method requires pulping, immediately after harvesting. During the pulping process, the skin from the bean is removed by a combination of processes that includes fermentation, treatment with alkali and enzymes, and mechanical removal in the

pulping machine. The process generates a large quantity of liquid and solid wastes due to the removal of skin and mucilages and repeated washing of the bean. The total quantity of effluent generated is as high as 60,000 - 70,000 litres with a maximum COD and BOD of 23 and 12 g/litre respectively. The total solid waste generated is around 60% of the processed fruit. The high organic content in the waste can be treated to produce a clean and eco-friendly fuel to replace the diesel used to run the pulping machine. These wastes are currently treated in stabilization ponds or composted. On an average in a 10 T/day processing unit, the consumption of diesel is 28 litres.

1.3.4 Food processing industry

The fruit and vegetable units form one of the major categories of the food-processing industry. The products of this industry includes jams and jellies, osmo-air dried fruits, raisins, dry apricots, dehydrated vegetables, pickles, wafers, chips, beverages, canned fruits and vegetables, concentrated pulps and juices, dehydrated vegetables, frozen fruits and vegetables etc. The production of fruits and vegetables has increased from 46.9 million tonnes to about 102 million tonnes during the period 1993-98. The total number of units in the year 1999-2000 was 5198 with a total capacity of 21 lakh tonnes. Most of these units (38%) are in the home-scale followed by cottage scale and small scale with 20% and 16%, respectively. The water and fuel consumption are quite high in these units, ranging between 2000 litres to 12000 litres and 50 kg to 100 kg of coal per tonne of fruit and vegetable processed. The total energy generated during the process of anaerobic digestion can also replace part of the energy requirement of the food-processing unit.

1.3.5 Municipal solid waste from small towns and cities

The total amount of municipal solid waste generated in India is 27.4 million tons. The average amount of waste generated in small towns is 20 TPD and the organic content is 65-75%. The biogas generation from the anaerobic digestion will be used to replace the LPG currently being used in residential areas. The annual consumption of LPG by households is 2.45 million tonnes. The amount of fuel replaced using biogas from wastes is 1.58 million tonnes. Currently these wastes are landfilled or composted. Under the MNES programme on the waste to energy, most of the projects are being set up for power generation.

Annexure 1 gives the total production and energy consumption of different industries.

2.0 Project Rationale and objective

2.1 Objectives

The project aims at developing a successful model for decentralized energy generation for rural and agro industries from available organic wastes. This will also result in the reduction of GHG emissions from the replacement of fossil fuel by eco-friendly fuels as well as emissions from the untreated waste. The main objective is to overcome the barriers associated with the adoption of the technology in different sectors and promote the technology by facilitating the information dissemination, and building the capacity of the local people. These in turn will be accomplished by setting up institutional structures. Thus the overall aim of the project is to reduce GHG emissions through the decentralized generation of energy from organic wastes and by creating markets for the wider adoption of waste to energy technologies by removing barriers. This project is in conformance with the UNFCCC objectives to stabilize the greenhouse gas concentrations below the prescribed limits and falls under the GEF operational area 6.

2.2 Project rationale

2.2.1 Importance of technology adaptation and removal of barriers

The technology of conversion of waste to energy is becoming popular for certain sectors, which generate high strength organic effluents. However certain small-scale industries and small towns and villages, are not making serious efforts to utilize the waste generated for useful resource recovery. Some of these industries lack awareness of the latest technologies and follow time-consuming conventional methods for the treatment of wastes. In addition to this, there is a need to train people in the operation and maintenance of the plant and make them aware of the importance of improved technologies. This project aims to address the utilization of the organic wastes for useful energy generation by removing the barriers related to technology, financial and implementation. Moreover the project addresses the problems of industries in clusters thereby facilitating the replication of the technology to wider areas.

The project will result in the establishment of a well-proven technology for selected industrial clusters of plantations, the food processing industry and municipal wastes from small towns and villages in southern states. Decentralized energy generation and reduction of the pollution are the national priorities.

2.2.2 Expected end-of-project situation

During the five-year duration of the project, it will complement the existing national and international programmes on waste utilization for useful energy and resource recovery. The project aims to implement the project model of bioenergy technology for the selected sectors- rubber, tea, coffee, food processing and municipalities. This would result in:

- The scale-up and adaptation of the technology for selected sites of different sectors;
  - 2 plants for the rubber industry
  - 2 units for the tea industry
  - 3 projects for coffee processing units
  - 6 projects of the fruit and vegetable processing sector
  - 3 plants for the municipal waste

- Improved awareness through wider dissemination activities in the form of:
  - Simplified pamphlets and brochures for the user on the importance of the efficient technology for treatment and re-use of the waste;
  - technical newsletters for technology suppliers;
  - summarized technical and financial details for the industrial and municipal associations; NGO's, policy makers, government bodies and funding agencies; through seminars, workshops and brainstorming sessions; field visits;
- Capacity building of
  - local industries for operation and maintenance;
  - entrepreneurs, NGO's and manufacturers;
  - municipal corporations, local bodies and industrial associations for management of the project
- Formation of energy service companies for the successful implementation and replication of the package through
  - technology support services
  - funding support for setting up plants
  - revolving funds

2.2.3 Target Beneficiaries

The immediate beneficiaries will be the industries and municipalities involved in the demonstration as they will be exposed to the available technology. Trained manpower, technology providers and manufacturers will improve the chances of successful implementation and reduce the risk associated with these projects. The financial institutions and local banks will also understand projects better facilitating their replication. This will improve the overall market for the waste-to-energy technology and also benefit the government in conserving the natural resources and evolvement of new policy measures.

2.2.4 Project strategy

The project idea is to implement the technology for the conversion of organic wastes from small-scale agro based industries and small towns and villages. This would have several components such as technology adaptation and standardization of the treatment technology for wastes of specific sectors, removal of the barriers associated

with the information and capacity building by dissemination activities and training programmes. This project will also remove financial barriers by mobilizing the credit facility from various financial institutions for waste-to-energy projects. A revolving fund would also be created in this project for making the project sustainable.

2.2.5 Technology scale-up and adaptation

The available technical know-how for the different identified areas will be assessed. The required modification and scale-up of the existing technology will be carried out at the respective sites. The performance of the plant will be tested for the efficiency.

2.2.6 Capacity building

The capacity building exercise will be conducted for personnel at different level.

- The training of technical personnel for the operation and maintenance of the plant.
- Training at the supervisory and managerial level for overall sustainability
- Local NGO's, manufacturers and entrepreneurs
- Financial institutions

2.2.7 Information barrier

The compiled information on the technological and financial aspects based on the experience of the project will be disseminated to various beneficiaries and stakeholders through aids such as brochures, pamphlets, newsletter, video films, journals, presentations, workshops, etc.

2.2.8 Financial barrier

Resources from financial institutions and local banks will be mobilized for the credit facility. A revolving fund will be created to enable the installation and successful operation of new plants. This will ensure smooth functioning of the concept after the project period.

3.0 Institutional framework for subsector

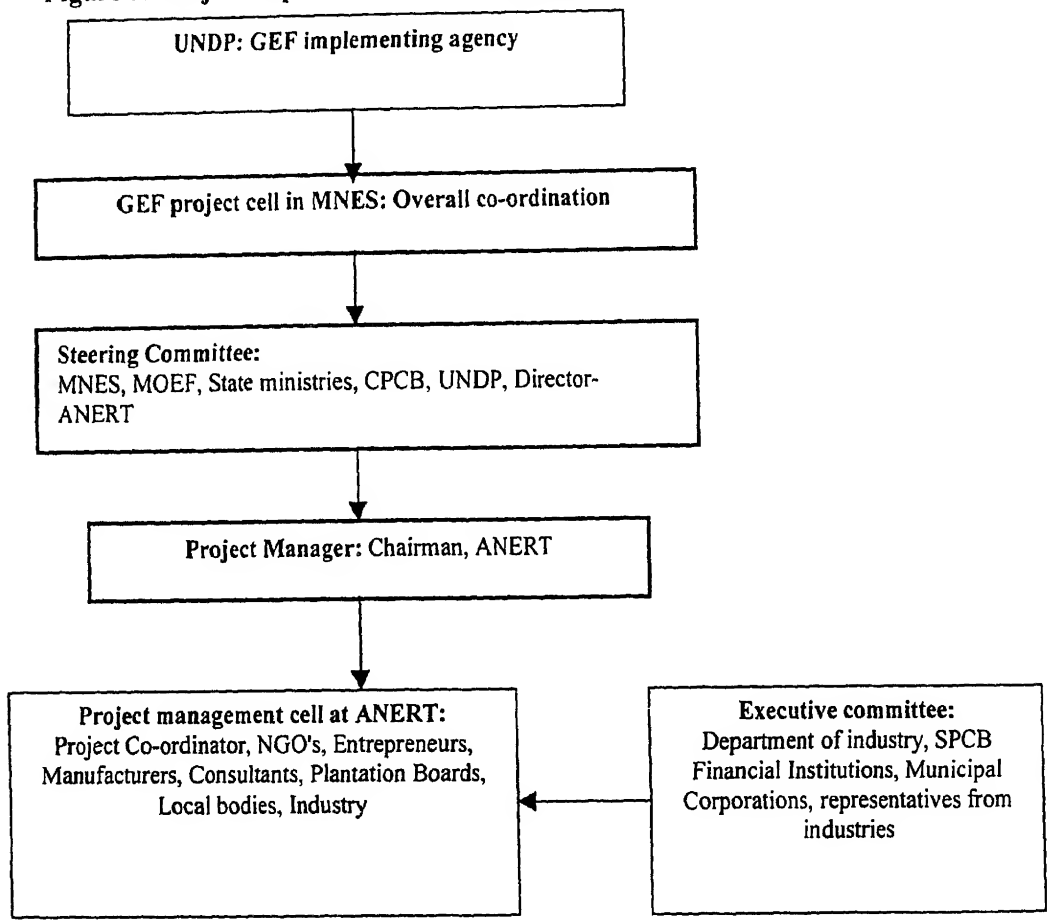
The Ministry of Non-conventional Energy Sources is the national level body for promoting the waste-to-energy programme in India. The Ministry is associated with state nodal agencies, which in turn collaborate with small-scale industrial associations, municipal corporations, NGO's, manufacturing companies etc. Indian Renewable Energy Development Agency (IREDA), Housing and Urban Development Corporation Ltd. (HUDCO), Local banks can provide financial assistance for implementation of the projects on energy generation from waste.

3.1 Project implementation arrangement

The UNDP will be the GEF implementing agency. The local implementing agency will be Agency for Non-conventional Energy and Rural Technology (ANERT). The project involves various organizations at national, state level and local agencies. The detailed institutional arrangement is given in Figure 1.

A cell will be created at the Ministry of non-conventional Energy Sources for the overall co-ordination of the project. A steering committee consisting of representatives of Ministry of Non-Conventional Energy Sources, Ministry of Environment and Forests, Ministry of Industry, state ministries, members from GEF implementing agency and director of the local implementing agency will be formed. The chairman of the local implementing agency (ANERT) who is also the secretary of the state department of Science and technology will be the project manager. The executive committee would consist of members of department of industry, state pollution control boards, funding agency, financial institutions and municipal corporations. A project management cell at ANERT headed by the Project Manager would be constituted. The project co-ordinator of the project management cell will work in close association with the local bodies, NGO's, entrepreneurs, manufacturers, technical support consultants for reviewing the project.

Figure 1: Project implementation arrangement



3.2 Prior ongoing assistance

MNES programme on waste to energy at national level

National project on biogas development

UNDP- GEF funded project on development of high rate biomethanation processes

However these programmes do not cover the small-scale industrial clusters and the wastes from small towns for the thermal energy generation, which contribute significantly towards GHG emissions.

3.3 Reasons for assistance from UNDP

The project will result in the reduction of GHG emissions from small-scale industries and towns. The total emissions that can be saved as a result of the demonstration plants from the rubber, tea and coffee industries over the life cycle of the plant of 15 years are 4493, 38419 and 5287 tons of CO_2 respectively. The total CO_2 abatement from the food processing industries and semi-urban solid wastes is 5656 and 36082 tons respectively. This would amount to a total of 85663 tons of CO_2 in the next 15

years. This is by replacing the fossil fuels currently used for the thermal applications in the industry by the clean and eco-friendly fuel. biogas.

Although the technology of utilization of organic waste to energy is well known. the applicability of working and well proven technology to specific substrates such as those from various agro-based industries is important. Moreover the project will result in decentralized energy generation and is mainly focussed on small-scale units existing in clusters thus making the concept more practical and replicable.

The project will also help in capacity building of the local manufacturers, entrepreneurs, industries, NGO's, local bodies, financial institutions. government organizations in waste to energy technology. This meets the objectives of operational program 6 of GEF- UNDP in promoting the projects on the adoption of renewable energy technologies that are sustainable leading.

4.0 Project components, activities and expected results

The development objective of this project is to reduce GHG emissions from selected sectors of rural and agro-industries by implementing changes in the present waste management practices and partial replacement of fossil fuels by an eco-friendly bioenergy. The project will specifically address the present barriers faced in adoption of technology for large-scale penetration.

4.1 Project objectives

4.1.1 Immediate objective 1

The immediate objective of the project is to install the plants of the best feasible technology in each identified sector. The easy handling of waste and other associated benefits of the technology will help in building the confidence in the technology. The partial replacement of fossil fuels will further contribute to the reduction in the GHG emissions.

4.1.2 Output and activities

a. Output

- Site selection

Activity

- Visits to clusters of industries
    - Sector-1
    - Sector-2
    - Sector-3
    - Sector-4
    - Sector-5
- Field interaction for gathering information regarding present practices of waste disposal

- Selection of industries which do not have a treatment plant for proper disposal of waste
- Feedback of industries regarding implementation of treatment plant
- Workshop for information dissemination to convince them of the need for proper waste disposal
- Selection of industries based on feedback obtained from them during the workshop and geographical location, so that project implementation is easier and replication is facilitated.

b. Output

- Technology selection

Activity

- Quantification and characterization of different waste streams in the selected sites.
  - Field interaction
  - Estimation of optimum capacity of plant
  - Evaluation of technology needs and options for each sector
  - Regional workshop
- Identification of appropriate technology
  - Literature review/survey
  - Study tour to various local and overseas industries, research institutions etc.
  - Technical viability of the technologies for each sector
- Selection of technologies
  - Comparison and economic analysis of different technologies
  - Adaptation of the technology for the respective sectors and for the required capacity
- Selection of technology suppliers and manufacturers
  - Cost inputs from various technology implementation institutions
  - Economic assessment and finalization of the manufacturer
- Tie-up with financial institution for loan facilities
- Preparation of DPR for individual demonstration projects

c. Output

- Installation of plants

Activity

- Estimation of land requirement for each demonstration unit
- Site selection for plant installation
- Interaction with national and international experts
- MoU between industry, municipal bodies and technology anchoring institution
- Construction of treatment plant
- Construction and installation; evaluation of demonstration units in each sector

d. Output

- Monitoring and evaluation

Activity

- Technical infrastructure upgradation of local institutions
- Performance evaluation at various demonstration units

Immediate objective 2

The second objective of the project is to remove the barriers in adoption of the technology on a large scale.

a. Output

- Preparation of different modes of information dissemination

Activity

- Media coverage at regional level
- Documentary films on demonstrated setups and benefits enjoyed
- Interviews of the users and their views
- Preparation of banners/posters and their exhibits at various exhibitions and workshops
- Preparation of brochures/leaflets and their dissemination to potential users
- Information dissemination through prepared posters/published materials/ brochures/emails/web etc.

b. Output

- Training programme and workshop

Activity

- Organization of lectures by
  - Technology providers
  - Financial institutions
  - Policies and environmental laws for waste management
- Demonstration of technologies
  - Preparation of table top models for various technologies
  - Training for installation of technologies through prepared models
  - Field visits to demonstrated setups
- Distribution and execution of advertising material
- Screening documentary films

c. Output

- Setting up of institutional mechanism

Activities

- Formation of a group of financial institutions for funding
  - Identification of possible funders
  - Interactive meetings with financial institutions

- Financial group and users meet
  - Brainstorming session
  - Identification of need-based funding schemes and policies
  - Information exchange for possible ways and extent of funding
  - Policy decisions for future funding
- Setting up of the ESCO
  - Identification of nodal agencies, NGOs, entrepreneurs for management of operation and maintenance of infrastructure setups
  - Creation of revolving fund for long term sustainability of the programme

Immediate objective 3

Capacity-building of the industries, NGO's, nodal agencies and other stakeholders, in order to make them competent to take further decisions regarding assessment of the suitability of the technology in each sector and operation and maintenance of the system.

a. Output

- Organization of training programme

Activity

- Need assessment
- Faculty identification
- Preparation of training modules for different sections of participants
- Preparation of guidelines for assessment of technical suitability and performance monitoring of the setups
- Overseas study tour and training programmes

b. Output

- Execution of training programmes

Activities

- For industries, manufacturers, research institutions and entrepreneurs
- For NGO's, local bodies and nodal agencies
- For policy makers and financial agencies

c. Output

- Evaluation of training programmes

5.0 Risks and sustainability

Risks in this project can be classified as:

a) Technical risks, as the project involves the application of waste treatment technology for the utilization of organic wastes for which field experience does not exist in India. To alleviate this risk, the project will involve several international consultants with expertise in the application of technology in the respective sectors.

b) Financial risks, due to insufficient contributions from any local funding agencies due to changes in their priority areas, minimal knowledge on the concerned area and a lack of confidence in the user. This could be taken care by awareness programmes, formation of energy service companies and the creation of a risk fund which are all important activities in the project.

c) Risk in replication, owing to a lack of exposure among users to the latest available technologies, relevant expertise to overcome any minor/major troubleshooting problems and lack of confidence and interest. This will be mitigated by awareness programmes and demonstrations of the proven technology after adaptation to the different sectors, capacity building for trouble free operation. Moreover the energy service companies formed will take care of the after sales service through the respective technical consultants.

6.0 Project review, reporting and evaluation

The executive and steering committees will review the project every year. The project monitoring committee will meet every quarter to assess the progress of the project and submit the report to the implementing agency, funding agencies, the executive and the steering committee. The monitoring and evaluation of the project will be carried out by the project monitoring committee through the experts appointed. The evaluation would be based on

- the number of treatment plants,
- their performance in terms of the biogas production and treatability,
- the capability of the user industries and the communities to maintain the plant,
- the extent of dissemination to various sources and
- the gains to beneficiaries in terms of the replacement of the fossil fuels and the improvement of the environment by reducing CO_2 emissions.

A final report will be submitted by the project director to the implementing agency.

7.0 Incremental costs assessment

The project goal is to establish an efficient waste management system for the agro-based industries and the semi urban areas and small towns. This would provide a clean and eco-friendly fuel and improve the environment by reducing the greenhouse gases, particularly CO_2 as a result of partial replacement of the conventional fossil fuels currently being used.

7.2 Baseline

In the industries considered in the project, namely the plantation industries (rubber, tea and coffee) and in the food processing industry, different types of fuels are being used. The baseline fuels used in different sectors are given in Table 1. In most of these industries, the wastes generated are treated by conventional aerobic methods with a large retention time. There are no treatment plants based on anaerobic digestion in any of these sectors.

Rubber

About 60% of the PLC (pre latex crepe) grade rubber and 100% of the TSR (technically specified rubber) or crumb rubber are furnace dried. This is followed by RSS (ribbed smoke sheet) grade where the percentage of furnace-dried rubber is 45. The fuel used is diesel and the average consumption is 25 litres per kg of the rubber processed.

Tea

More than 90% of the energy in this industry is required for thermal applications to remove moisture during drying and withering. In northeast India, coal is the most common fuel and in south India, wood is used to an extent of 60%. Furnace oil and coal are also used and the percentage is around 20% each. Most tea plantations have locally developed wasteland-growing trees to be used as fuel. Hence it has not been considered to calculate the incremental costs. As the proportion of both coal and furnace oil is the same and because biogas generated by the digestion of waste can only partially replace the fossil fuel currently used, only one baseline fuel has been chosen. In this case, the fuel chosen is furnace oil as the calorific value is higher and replacement of this can give at least the minimum benefits if biogas is used.

Coffee

Diesel is used in pulping operations during coffee processing. The average consumption is 2.8 l for processing 1 ton of coffee berries. The briquettes obtained from the waste generated during curing process- husk are used to replace the coal currently used in other small-scale industries such as tobacco drying. From a 20 T/d curing unit, 40 T of briquettes can be produced. The baseline fuel is taken as coal for the pelletisation plant producing briquettes from coffee husk.

Food processing

In this sector, a large amount of fuel consumed (wood, coal and diesel) is in the concentration and drying operation. However, coal is used predominantly. Hence this is chosen as the baseline fuel.

Municipal solid wastes

The solid wastes generated in small cities and towns are currently dumped and in most cases, the dumping ground is close to residential localities. The biogas generated from these wastes can be utilized to replace the LPG. baseline fuel being used in the colonies.

Table 1: Types of fuels used in different sectors

Sectors	*Baseline fuel*
Rubber	Diesel
Tea	Coal/furnace oil/fuel wood
Coffee	Diesel/coal
Food processing	Coal/LPG/diesel
Municipal solid wastes	LPG

Currently, wastes generated from all the sectors are either untreated or treated by the conventional aerobic method and do not result in useful energy recovery. The major reason for the non-penetration of the improved waste treatment technology to these small-scale sectors is that there is no demonstration of proven technology in the field. Technologies have been tried and are being used for high strength wastes from large-scale industries. Hence certain adaptability of the technology is needed for the specified sectors. Other barriers that have prevented the intervention of the technology are lack of awareness, sufficient capability and the necessary finance for setting up the plant. Hence the support from GEF is needed to overcome these barriers and to establish the working model for these sectors.

7.3 Alternative

In the alternative scenario, we propose to set up waste treatment plants and the recovery of energy from them will be used to replace fossil fuels currently used by the industry. This will save fuels and reduce GHG emissions in each sector.

Technology demonstration projects

Five different sectors have been identified where the waste to energy technology will be demonstrated based on biomethanation or pelletization. The sectors were selected on the basis of the potential of waste generated, biogas generated, the energy requirement and replication potential due to the presence of these industries in clusters. The total number of demonstration plants in each sector is given in Table 2. The activity of the setting up of the plants will commence in the third year after the finalization and adaptation of the selected technology for each sector. The capacities

and number of plants in each sector has been chosen on the basis of the average quantity of waste generated in different sectors.

Table 2 Sectors and number of demonstration plants

Sectors	*No. of plants*
Rubber	2
Tea	2
Coffee	3
Food processing	6
Municipal solid waste	3
Total	16

Setting up of these units will build confidence in the technology. This will facilitate replication of the technology. The cost involved in this will be shared by the user industries and the municipalities in the form of loans from financial institutions and government subsidy. A part of the costs relating to the plants installation, such as those for meeting the additional risk amount for these pioneer projects, technical know-how for certain sectors and the necessary equipment for strengthening the local institution capabilities are proposed to be borne by GEF.

Information dissemination and training programs

The importance of the technology and the improved environmental conditions as a result of the implementation of these should be widely disseminated. The capacity building exercise should be carried out at different levels i.e for the industry staff for operation and maintenance, at the managerial level for the application of the most appropriate technology and on the funding opportunities, to the financial agencies on the funding for the waste to energy projects in the specific sectors. As the technology will be largely dependent on the substrate, training programmes should be conducted for different sectors. This will enable local research institutes such as Rubber Research Institute, Tea Research Institute etc. to understand and develop the technical solutions to various problems associated with the treatment plants. Currently there are few training programmes being conducted by the government on the above issues. There are also few national consultants working in these sectors. Hence some of the training programmes should have provisions for visits by international consultants/experts and for the study tours and training of local experts.

The major financial component will be from the GEF. A small percentage will be contributed by the users in the form of participation fee, by financial agencies such as the SIDBI under the environmental management program and the existing government programs.

Formation of energy service companies (ESCos)

There is a need to have energy service companies for the implementation of the developed project model and for ensuring their sustainability and replication. Different ESCo's will be formed which will be based on the location and sector. For the setting up of these companies and for their initial support, funding is required. The company will become sustainable later with increased market demand. Figure 2 shows the implementation of project model through ESCo.

Global environmental objective

The global environmental objective of this project is the reduction of GHG emissions by the use of cleaner fuel from wastes in place of conventional fossil fuels. This project will become sustainable and can be replicated once the barriers are removed. This project is consistent with the GEF Operational Program 6, "Promoting the adoption of renewable energy by removing barriers and reducing implementation costs".

The total baseline costs and the cost of alternatives are provided in the incremental cost matrix. The total cost of the project is US$ 9.92 million. Compared with the baseline cost of 2.55 US$ million, the net incremental cost is US$ 6.29 million.

Global environmental benefits

The project will result in the abatement of 85663 tonnes of CO_2 taking into account the replacement of fuels by biogas in the 16 planned demonstration units over the plant life of 15 years.

7.4 Incremental cost per tonne of CO_2 abatement calculation for the 16 waste-to-energy plants

For each demonstration plant, the cost per tonne of CO_2 abated is calculated based on the incremental cost for the alternative technology over existing baseline technology in that sector and the corresponding incremental CO_2 emissions abated using the alternative technology. The detailed calculations are given in Annexure III.

The incremental cost is calculated using the Net Present Value (NPV) Method, with certain assumptions being considered for each sector (Sets of assumptions for each sector have been compiled in Annexure II). This cost is actually the capital cost for waste treatment plant technology (including installation costs etc.) and O & M costs excluding fuel savings (as a result of replacement of conventional fuel with

generated waste). The amount of energy generated in each plant and the quantity of fossil fuel that can be replaced is based on certain assumptions as it is dependent on the waste. The CO_2 emissions for different sectors have been estimated using the emission factors for different baseline fuels as per the IPCC guidelines for National Greenhouse gas inventories.

The incremental cost per tonne of CO_2 abated for each sector has been given in Table 3.

Table 3: Incremental cost per tonne of CO_2 abated for different sectors

Sector	*Cost/T of CO2 abated (US \$/T)*
Rubber	0.00
Tea	0.00
Coffee	0.01
	2.96
Food processing	0.05
	0.03
	0.01
MSW	0.00

Note: In the case of coffee processing, different waste treatment technology is proposed for the different waste streams. Waste to energy plant based on biomethanation will be used for the pulp generated by wet processing. The coffee husk, which is a dry waste, will be briquetted and used to replace the conventional fuel currently used for thermal applications.

In food processing industries, the capacity of the plant varies widely. A range of capacity of the waste treatment plants will be installed in this project.

The figures on cost per tonne of CO_2 abated in each sector calculated above indicate a very low/almost no cost implying a win-win situation for the industry and the investors of the technology.

The incremental cost of the project has been given in the incremental cost matrix (Annexure IV). The baseline for the technology adaptation and demonstration activity is the conventional methods of treatment that will be used in the absence of waste to energy plants. Although efforts are being taken by the Government for the capacity building and information dissemination activities related to the waste to energy, there are no institutional mechanisms such as ESCo for these types of projects for ensuring the wider penetration of the projects. The annutised incremental cost has been estimated using a CRF factor of 0.15.

Here CRF is economic CRF and is a function of economic discount rate and the system lifetime given as

$$CRF = \frac{r}{1-(1+r)^{(-n)}}$$

where r= marginal economic return on capital

n= system lifetime

8. Budget

The total budget of the project spread over 5 years is US$ 9.92 million. The detailed budget for each year and for different activities for each sector is given in Annexure VI. As the incremental cost of the project is US$ 6.29 million, the requested financial support from GEF is US$ 6.29 million. Co-financing from other sources includes a contribution from the Central government, state government and users contribution and also from the nodal agencies.

8.1 Inputs

8.1.1 Contribution from GEF:

Inputs from GEF will be required for meeting the increased subsidy rates for the risks associated with the initial projects and also for meeting the expenses related to the capacity building, dissemination activities. This will also include the initial fund required for the formation of ESCo's.

8.1.2 Contribution from MNES:

This will include the subsidy for the waste to energy projects and the existing financial support for the capacity building and information dissemination.

8.1.3 Contribution from industries

This component will be in kind in terms of land, manpower, utilities and a component for training. Partial cost for the demonstration plant will be arranged by the industries through financial institutions.

8.1.4 Contribution by the implementing agency

The inputs will be mainly in kind in the form of infrastructure facilities for the setting up of the office of the project manager and the project management cell.

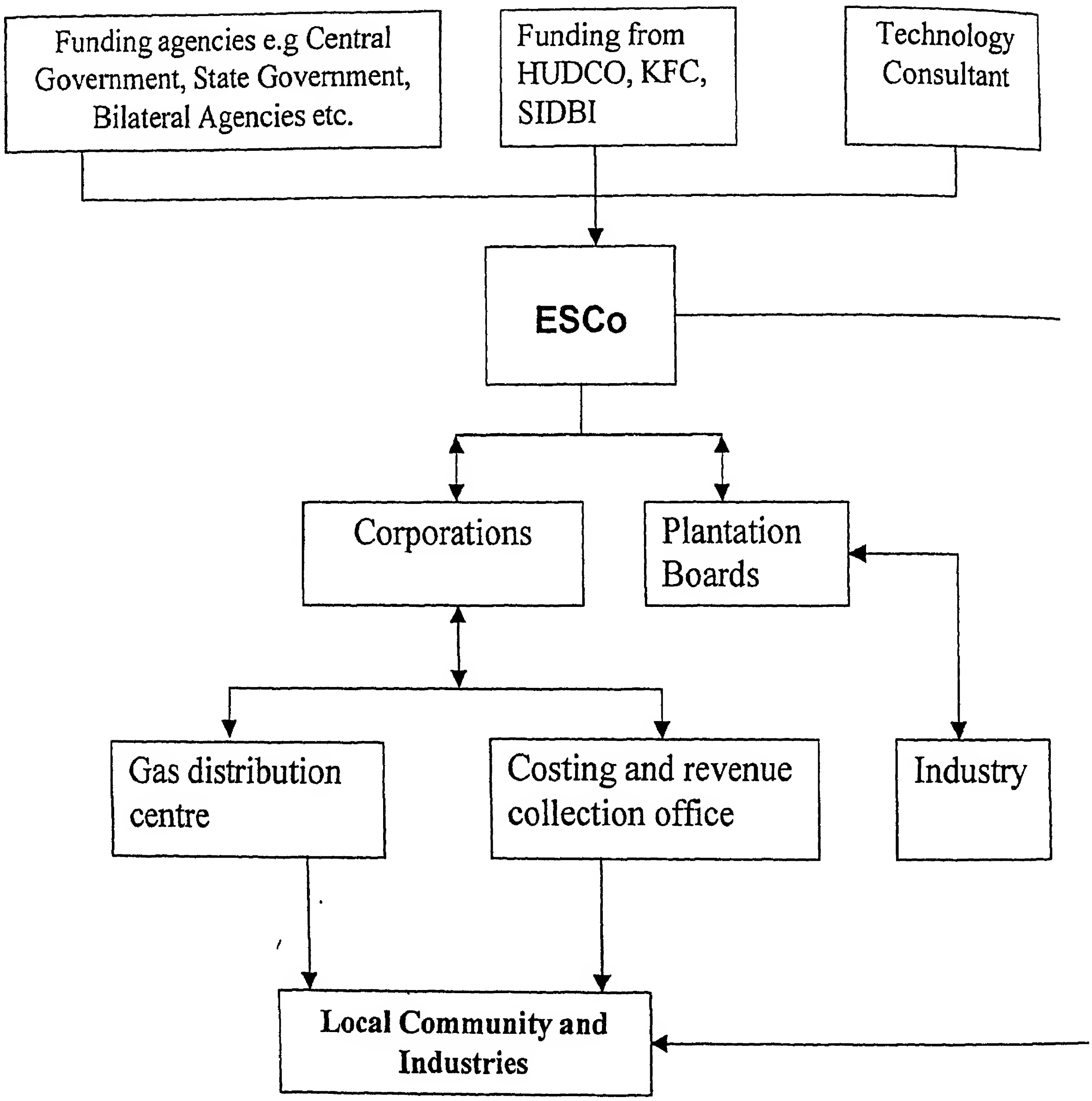


Figure 2 Execution of project model through ESCo

Annexure I Production and energy consumption in different sectors

Rubber

Total Units		Total Production	Energy consumption
Small holdings ('000 Hectares)	Estates	('000 Tonnes)	
484	69	620	20-30 GJ/tonne

Tea

Total Number of units	Total area ('000 hectares)	Total Production ('000 tonnes)	Energy consumption
37,000	432	870	4-10.4 kWh/kg

Coffee

Total units		Total area ('000 hectares)		Total production ('000 tonnes)	Energy Consumption
Small holdings	Estates				
154211	2600	226	346	292	2.8 l/tonne

Food processing unit

Total Units	Total Production ('000 tonnes)	Energy consumption
5198	940	2-10 kW

Annexure II Parameters for incremental cost calculations

Parameters	**Rubber**	**Tea**	**Coffee**	**Food processing**	**Municipal solid waste**
Average waste production (T/d)	200 m^3/d	10	10	0.5, 1, 10	20
Waste production (T/T)	20 m^3/ton	0.04	0.6	0.5	-
Biogas yield	20 m^3/ ton	0.2 m^3/kg TS	49.6 m^3/ton and 2 tons of briquette/ T of waste	0.375 m^3/kgVS	0.25 m^3/kg TS
Plant cost (US $/T)	375 US $/$m^3$	28000	28000	28000	28000
Plant life (Years)	15	15	15	15	15
Depreciation rate (%)	10	10	10	10	10
O & M Cost (%)	5	5	5	5	5
Fuel used	Diesel	Furnace oil	Diesel and coal	coal	LPG
Density of fuel (kg/l)	0.87	0.96	0.87	-	-
Cost of fuel (Rs/l)	18	10	18	2.5/kg	20/kg
Calorific value of fuel (kCal/kg)	10,350	9850	10,350	4340	11300
Consumption of fuel	25 l/ton	0.73 million m^3/t	28 l/ ton and 312.5 kg /ton	100 kg/ton	0.51 kg /person/month

ANNEXURE III

Calculation of Incremental Cost for 16 Biomethanation Plants in India

Sector-wise	Units	Rubber	Tea	Coffee 1	Coffee 2	FP(0 5T/D)	FP(1T/D)	FP(10 T/D)	MSW	additional cost (pl FP(10 T
Production (per average plant)	TMT	3 65	100 00	2 90	0 05	0 37	0 73	7 30	7 30	
Total fuel cost before setting up WTP	Rs	1688125	738102874	1502200	92166	91250	182500	1825000	3672000	
Net fuel cost(total)	Rs	938222	734295767	615630	0	73510	147020	735099	1249	
No of demo plants	No	2	2	2	1	2	2	2	3	
Cost of each demo plant (CC)	Rs	3600000	10000000	10000000	6000000	500000	1000000	10000000	20000000	12100000
CO2 abated per demo plant	T	136 15	1164 21	133 60	63 27	34 99	69 98	66 40	721 66	

Year wise total additional cost		*year 3 (2004/05)*	*year 4(2005/06)*	
Rubber	Rs	1896000	1896000	
Tea	Rs	2496000	2496000	
Coffee 1	Rs	4992000	0	
Coffee 2	Rs	0	1609000	
FP(0 5T/D)	Rs	596000	596000	
FP(1T/D)	Rs	696000	696000	
FP(10T/D)	Rs	2496000	2496000	
MSW	Rs	10972000	7466000	2970000

Sector -Rubber		Base Year			Project Life						
			1	2	3	4	5	6	7	8	
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	3600000	3600000	0	0	0	0	
Additional cost	Rs	0	0	0	1896000	1896000	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs				180000	360000	360000	360000	360000	360000	
Additional/Net fuel cost	Rs	3376250	3376250	3376250	2626347	1876444	1876444	1876444	1876444	1876444	
CRF		0 15									
Annutised capital cost	Rs				806946	1613892	1613892	1613892	1613892	1613892	
Total incremental cash outflow	Rs				4926097	4356194	-1139806	-1139806	-1139806	-1139806	
Total cash outflow/T of production	Rs/T				1350	597	-156	-312	-312	-312	
CO2 abated	T				136	272	272	272	272	272	
NPV of incremental cost/T of production	Rs	96			Rs/T	0 48	annutised incremental cost/T of prodcution				
Total annutised cost/T of production	Rs/T				65	65	65	65	65	65	
NPV cost/T of CO2 abated	Rs/T	0 02									
NPV cost/T of CO2 abated	$/T	0 00									

Sector -Tea		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	10000000	10000000	0	0	0	0	
Additional cost	Rs	0	0	0	2496000	2496000	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs				500000	1000000	1000000	1000000	1000000	1000000	1
Additional/Net fuel cost	Rs	1476205747	1476205747	1476205747	1472398641	1468591534	1468591534	1468591534	1468591534	1468591534	1468
Annutised capital cost	Rs				1834716	3669431	3669431	3669431	3669431	3669431	3
Total incremental cash outflow	Rs				9188893	5881787	-6614213	-6614213	-6614213	-6614213	-6
Total cash outflow/T of production	Rs/T				92	29	-33	-33	-33	-33	
CO2 abated	T				1164	2328	2328	2328	2328	2328	
NPV of incremental cost/T of production	Rs	-74									
Total annutised cost/T of production	Rs/T				-15	-15	-15	-15	-15	-15	
Annutised cost/T of CO2 abated	Rs/T				-0 01	0	0	0	0	0	
NPV cost/T of CO2 abated	Rs/T	-0 03			0 00						
NPV cost/T of CO2 abated	$/T	0 00									

Sector -Coffee 1		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	20000000	0	0	0	0	0	
Additional cost	Rs	0	0	0	4992000	0	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs				1000000	1000000	1000000	1000000	1000000	1000000	1
Additional/Net fuel cost	Rs	3004400	3004400	3004400	1231260	1231260	1231260	1231260	1231260	1231260	1
Annutised capital cost	Rs				3669431	3669431	3669431	3669431	3669431	3669431	3
Total incremental cash outflow	Rs				24218860	-773140	-773140	-773140	-773140	-773140	-
Total cash outflow/T of production	Rs/T				4176	-133	-133	-133	-133	-133	
CO2 abated	T				267 196	267 196	267 196	267 196	267 196	267 196	2
NPV of incremental cost/T of production	Rs	2918									
Total annutised cost/T of production	Rs/T				499	499	499	499	499	499	
Annutised cost/T of CO2 abated	Rs/T				2	2	2	2	2	2	
NPV cost/T of CO2 abated	Rs/T	1			0 04						
NPV cost/T of CO2 abated	$/T	0 01									

Sector -Coffee 2		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	0	6000000	0	0	0	0	
Additional cost	Rs	0	0	0	0	1609000	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs					300000	300000	300000	300000	300000	3
Additional/Net fuel cost	Rs	0	0	0	0	0	0	0	0	0	
Annutised capital cost	Rs					1117186	1117186	1117186	1117186	1117186	11
Total incremental cash outflow	Rs					6000000	300000	300000	300000	300000	3
Total cash outflow/T of production	Rs/T					120000	6000	6000	6000	6000	
CO2 abated	T					63 268	63 268	63 268	63 268	63 268	6
NPV of incremental cost/T of production	Rs	143630									
Total annutised cost/T of production	Rs/T					28344	28344	28344	28344	28344	
Annutised cost/T of CO2 abated	Rs/T		$/T		9 3	448	448	448	448	448	
NPV cost/T of CO2 abated	Rs/T	142									

Plant Life											
	10	11	12	13	14	15	16	17	18	19	Total
2011/12	2012/13	2013/14	2014/15	2015/16							
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
	360000	360000	360000	360000	360000	360000	360000	360000	360000	360000	
	1876444	1876444	1876444	1876444	1876444	1876444	1876444	1876444	1876444	1876444	
	1613892	1613892	1613892	1613892	1613892	1613892	1613892	1613892	1613892	1613892	
	-1139806	-1139806	-1139806	-1139806	-1139806	-1139806	-1139806	-1139806	-1139806	-1139806	
	-312	-312	-312	-312	-312	-312	-312	-312	-312	-312	
	272	272	272	272	272	272	272	272	272	272	4493
	65	65	65	65	65	65	65	65	65	65	

Plant Life											
	10	11	12	13	14	15	16	17	18	19	
2011/12	2012/13	2013/14	2014/15	2015/16							
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	
	1468591534	1468591534	1468591534	1468591534	1468591534	1468591534	1468591534	1468591534	1468591534	1468591534	
	3669431	3669431	3669431	3669431	3669431	3669431	3669431	3669431	3669431	3669431	
	-6614213	-6614213	-6614213	-6614213	-6614213	-6614213	-6614213	-6614213	-6614213	-6614213	
	-33	-33	-33	-33	-33.	-33	-33	-33	-33	-33	
	2328	2328	2328	2328	2328	2328	2328	2328	2328	2328	38419
	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	
	0	0	0	0	0	0	0	0	0	0	

Plant Life										
	10	11	12	13	14	15	16	17	18	
2011/12	2012/13	2013/14	2014/15							
	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	
	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	
	1231260	1231260	1231260	1231260	1231260	1231260	1231260	1231260	1231260	
	3669431	3669431	3669431	3669431	3669431	3669431	3669431	3669431	3669431	
	-773140	-773140	-773140	-773140	-773140	-773140	-773140	-773140	-773140	
	-133	-133	-133	-133	-133	-133	-133	-133	-133	
	267 196	267 196	267 196	267 196	267 196	267 196	267 196	267 196	267 196	4275 137
	499	499	499	499	499	499	499	499	499	
	2	2	2	2	2	2	2	2	2	

Plant Life											
	10	11	12	13	14	15	16	17	18	19	
2011/12	2012/13	2013/14	2014/15	2015/16							
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
	0	0	0	0	0	0	0	0	0	0	
	1117186	1117186	1117186	1117186	1117186	1117186	1117186	1117186	1117186	1117186	
	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	
	63 268	63 268	63 268	63 268	63 268	63.268	63.268	63 268	63 268	63.268	1012 296
	28344	28344	28344	28344	28344	28344	28344	28344	28344	28344	
	448	448	448	448	448	448	448	448	448	448	

NPV cost/T of CO2 abated	S/T	3 0									

Sector -Food Processing (0.5T/D)		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	500000	500000	0	0	0	0	
Additional cost	Rs	0	0	0	596000	596000	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs	0	0	0	25000	50000	50000	50000	50000	50000	
Additional/Net fuel cost	Rs	182500	182500	182500	164760	147020	147020	147020	147020	147020	
Annutised capital cost	Rs				160919	321839	321839	321839	321839	321839	
Total incremental cash outflow	Rs				1103260	1110520	14520	14520	14520	14520	
Total cash outflow/T of production	Rs/T				1511	1521	20	20	20	20	
CO2 abated	T				35	70	70	70	70	70	
NPV of incremental cost/T of production	Rs	2670									
Total annutised cost/T of production	Rs/T				461	461	461	461	461	461	
Annutised cost/T of CO2 abated	Rs/T				13	7	7	7	7	7	
NPV cost/T of CO2 abated	Rs/T	2									
NPV cost/T of CO2 abated	$/T	0									

Sector -Food Processing (1T/D)		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	1000000	1000000	0	0	0	0	
Additional cost	Rs	0	0	0	696000	696000	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs				50000	100000	100000	100000	100000	100000	
Additional/Net fuel cost	Rs	365000	365000	365000	329520	294039	294039	294039	294039	294039	
CRF		0 18									
Annutised capital cost	Rs				249014	498028	498028	498028	498028	498028	
Total incremental cash outflow	Rs				1710520	1725039	29039	29039	29039	29039	
Total cash outflow/T of production	Rs/T				2343	1182	20	20	20	20	
CO2 abated	T				70	140	140	140	140	140	
NPV of incremental cost/T of production	Rs	3142									
Total annutised cost/T of production	Rs/T				361	361	361	361	361	361	
NPV cost/T of CO2 abated	Rs/T	1									
NPV cost/T of CO2 abated	$/T	0 0									
Annutised cost/T CO2 abated	Rs/T				5	3	3	3	3	3	
			$/T		0						

Sector -Food Processing (10T/D)		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	0	10000000	0	0	0	0	
Additional cost	Rs	0	0	0	0	2496000	0	0	0	0	
Existing O&M cost	Rs										
New O&M cost	Rs	0	0	0	0	500000	500000	500000	500000	500000	[illegible]
Additional/Net fuel cost	Rs	1825000	1825000	1825000	1825000	1470197	1470197	1470197	1470197	1470197	[illegible]
Annutised capital cost	Rs				0	1834716	1834716	1834716	1834716	1834716	[illegible]
Total incremental cash outflow	Rs				0	12641197	145197	145197	145197	145197	
Total cash outflow/T of production	Rs/T				0	1732	20	20	20	20	
CO2 abated	T				66 43	132 86	132 86	132 86	132 86	132 86	
NPV of incremental cost/T of production	Rs	1488									
Total annutised cost/T of production	Rs/T				0	271	271	271	271	271	
Annutised cost/T of CO2 abated	Rs/T				0	2	2	2	2	2	
NPV cost/T of CO2 abated	Rs/T	1									
NPV cost/T of CO2 abated	$/T	0 014									

Sector -MSW		Base Year			Project Life						
			1	2	3	4	5	6	7	8	9
		2001/02	*2002/3*	*2003/04*	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2010/11*
Capital cost	Rs	0	0	0	64200000	32100000	0	0	0	0	
Additional cost	Rs	0	0	0	10972000	7466000	2970000	2970000	2970000	2970000	[illegible]
Existing O&M cost	Rs										
New O&M cost	Rs	0	0	0	3210000	4815000	4815000	4815000	4815000	4815000	[illegible]
Additional/Net fuel cost	Rs	11016000	11016000	11016000	3674499	3748	3748	3748	3748	3748	
Annutised capital cost	Rs				11037072	16846320	16846320	16846320	16846320	16846320	[illegible]
Total incremental cash outflow	Rs				71040499	33368748	-3227252	-3227252	-3227252	-3227252	[illegible]
Total cash outflow/T of production	Rs/T				4866	1524	-442	-442	-442	-442	
CO2 abated	T				1443 31	2164 97	2164 97	2164 97	2164 97	2164 97	2
NPV of incremental cost/T of production	Rs	2838									
Total annutised cost/T of production	Rs/T				473	486	486	486	486	486	
Annutised cost/T of CO2 abated	Rs/T				0	0	0	0	0	0	
NPV cost/T of CO2 abated	Rs/T	0 1									
NPV cost/T of CO2 abated	$/T	0									

Cost per tonne of CO2 abated	No of demo plants		cost/T of CO2 abated
Sectors	Year 3	Year 4	US$/T
Rubber	1	1	0 00
Tea	1	1	0 00
Coffee 1	2	0	0 01
Coffee 2	0	1	2 96
FP(0 5T/D)	1	1	0 05
FP(1T/D)	1	1	0 03
FP(10T/D)	0	1	0 01
MSW	2	1	0 00

Plant Life

	10	11	12	13	14	15	16	17	18	19	
12	2012/13	2013/14	2014/15	2015/16							
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
	147020	147020	147020	147020	147020	147020	147020	147020	147020	147020	
	321839	321839	321839	321839	321839	321839	321839	321839	321839	321839	
	14520	14520	14520	14520	14520	14520	14520	14520	14520	14520	
	20	20	20	20	20	20	20	20	20	20	
	70	70	70	70	70	70	70	70	70	70	1155
	461	461	461	461	461	461	461	461	461	461	
	7	7	7	7	7	7	7	7	7	7	

Plant Life

	10	11	12	13	14	15	16	17	18	19	
12	2012/13	2013/14	2014/15	2015/16							
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	
	294039	294039	294039	294039	294039	294039	294039	294039	294039	294039	
	498028	498028	498028	498028	498028	498028	498028	498028	498028	498028	
	29039	29039	29039	29039	29039	29039	29039	29039	29039	29039	
	20	20	20	20	20	20	20	20	20	20	
	140	140	140	140	140	140	140	140	140	140	2309
	361	361	361	361	361	361	361	361	361	361	
		Rs/T		5 annutised incremental cost/T of prodcution							

3

Plant Life

	10	11	12	13	14	15	16	17	18	19	
12	2012/13	2013/14	2014/15	2015/16	2015/17	2015/18	2015/19	2015/20	2015/21		
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
	500000	500000	500000	500000	500000	500000	500000	500000	500000	500000	
	1470197	1470197	1470197	1470197	1470197	1470197	1470197	1470197	1470197	1470197	
	1834716	1834716	1834716	1834716	1834716	1834716	1834716	1834716	1834716	1834716	
	145197	145197	145197	145197	145197	145197	145197	145197	145197	145197	
	20	20	20	20	20	20	20	20	20	20	
	132 86	132 86	132 86	132 86	132 86	132 86	132 86	132 86	132 86	132 86	2192 19
	271	271	271	271	271	271	271	271	271	271	
	2	2	2	2	2	2	2	2	2	2	

Plant Life

	10	11	12	13	14	15	16	17	18	19	
12	2012/13	2013/14	2014/15	2015/16	2015/17	2015/18	2015/19	2015/20	2015/21		
	0	0	0	0	0	0	0	0	0	0	
	2970000	2970000	2970000	2970000	990000	990000	990000	990000	990000	990000	
	4815000	4815000	4815000	4815000	4815000	4815000	4815000	4815000	4815000	4815000	
	3748	3748	3748	3748	3748	3748	3748	3748	3748	3748	
	16846320	16846320	16846320	16846320	16846320	16846320	16846320	16846320	16846320	16846320	
	3227252	-3227252	-3227252	-3227252	-5207252	-5207252	-5207252	-5207252	-5207252	-5207252	
	-442	-442	-442	-442	-713	-713	-713	-713	-713	-713	
	2164 97	2164 97	2164 97	2164 97	2164 97	2164 97	2164 97	2164 97	2164 97	2164 97	36082 81
	486	486	486	486	486	486	486	486	486	486	
	0	0	0	0	0	0	0	0	0	0	

85663 281

Annexure IV Incremental cost matrix

Project component	Baseline scenario	Alternative scenario	Increment
1.Technology selection and adaptation for waste treatment plants for different sectors	Currently the wastes generated from the various sectors are either untreated or uses the conventional aerobic or composting technology.	The waste treatment plant for the specific substrate would be developed and installed	Package for energy recovery from waste will be available for different substrates
Cost (US $)	1527084	6127896	4600813
2. Information dissemination	The ministry of non-conventional energy sources, under its waste to energy programme conducts workshops and brings out publication materials based on the developments taking place in the field of waste processing and treatment technology	Preparation of wide range of dissemination and audio visual materials to different categories of stakeholders; training for users and financial agencies	Compiled information on the management and technology of the waste treatment practices and successful installations
Cost (US $)	125000	222916.7	97916.7
3. Setting up of institutional mechanism	Presently no system for ensuring the sustainability and replicability	Formation of energy service companies and creation of revolving fund	Availability of technical and financial support for the long term sustainability of the project
Cost (US $)	0	447916.7	447916.7
4.Capacity building	MNES conducts training programs, organizes workshops, study tours and conferences		

Cost (US $)	850000	1997917	1147917
5 Domestic benefits	Currently no treatment plants for energy generation from waste. Fossil fuel are used which lead to various emissions	Efficient waste to energy plant Fuel savings Waste management Local environmental benefits (SO_x, NO_x, CO, Particulate matter)	Improved hygienic conditions due to waste treatment, control of environmental pollution due to replacement of fossil fuels
6. Global environmental benefits	Lack of improved waste treatment technologies, conventional technologies is being used in the selected sectors		CO_2 emissions abated
Tonnes of CO_2 abated			85663.281
7. Incremental cost (US $)	2554166	8348729	6294563.4
8.Annutised incremental cost/tonne of CO2 abated (US $/t)			11.0

Annexure V Time Schedule of activities

Activity component	Year 1	Year 2	Year 3	Year 4	Year 5
Setting up of project management office					
Sites finalisation, Technology selection and adaptation					
Plants installation					
Information dissemination					
Setting up of institutional mechanism					
Organisation and execution of training program					
Evaluation					

Annexure VI

Budget

Activity component	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total (US $)**
Installation of plants	145833	843750	3849875	1641979	188125	6669562
Information dissemination and setting up of institutional mechanism				660416	10416	670833
Capacity building, organisation of training programs and evaluation			541666	758333	697916	1977083
Setting up of project management office and project monitoring	107083	107083	121145	118020	132083	585416
Total	252916	950833	4512688	3178750	1028542	9923729